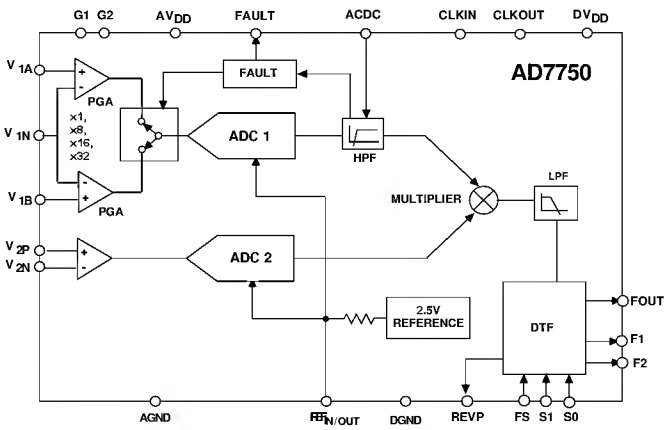
PFC for Energy Metering with On-Chip Fault Detection

Preliminary Technical Data — AD7751*

FEATURES

Three single-ended Analog Input Channels
2 Current Channels for Phase and Neutral monitoring
1 Voltage Channel
Two quadrant multipication
Real Power Measurement (Magnitude Only)
Less than 0.3% Error overa dynamic range of 1000
Gain Select of 1, 4, 8 and 16 on the Current Channels
On-Chip Reference (2.5V ±8%) with external reference overdrive capability
Choice of output pulse frequencies available (Pins F1 and F2)
High Frequency pulse output for Calibration Purposes (FOUT)
Reverse Power Polarity detection with logic output Indicator (REVP)
Earth Leakage (Fault) detection with logic output Indicator (FAULT)
Accurate Billing in Fault Mode (1%).
Single 5 V Supply and Low Power

FUNCTIONAL BLOCK DIAGRAM



GENERAL DESCRIPTION

The AD7751 is a Product-to-Frequency Converter (PFC) for use in single phase power measurement applications. The part contains the equivalent of two channels of A/D conversion, a multiplier, a digital-to-frequency converter, a reference and other conditioning circuitry. The Current channels (V_{1A} and V_{1B}) are single ended with respect to AGND and have pin programable gain amplifiers (PGAs) with gain selections of 1, 4, 8 and 16. A high-pass filter can be switched into the signal path of the Current channels to remove any d.c. offsets. The Voltage channel (V_2) is also single ended with a fixed gain of 2.

The AD7751 provides two low frequency pulse outputs (F1 and F2) for stepper motor or impulse counter drive. There is also a higher frequency pulse output (FOUT) which can be used for calibration purposes. The frequency of the outputs F1, F2 and FOUT is proportional to the product of V_{1A} or V_{1B} (which ever is the bigger signal - see below) and V_2. The output of the multiplier is low pass filtered before being converted to a frequecy, therefore the frequency is proportional to real power.

The AD7751 contains unique earth leakage or pilfer detection circuitry. The current in the Phase and Neutral wires is continuously monitored by the AD7751. If there is a greater that 20% difference between the two currents then the logic output (FAULT) will become active and the power measurement will be made using the larger of the two currents. The AD7751 will also detect negitive power, e.g. if the Phase and Neutral wires are reversed at the meter input terminals. This is indicated by the logic output (REVP) going active. The AD7751 will continue to calculate the power correctly in this mode.de Only Mode, see Reverse Polarity Indicator.
The error as a percent (%) of reading is less that 0.3% over a dynamic range of 1000:1.

The AD7751 is fabricated on 0.6u CMOS technology; a process that combines low power and low cost. The AD7751 is available in 24 Pin DIP and 24 Lead SOIC packages.

PRODUCT HIGHLIGHTS

1. Power to Frequency conversion with a maximum error of 0.3% over a dynamic range of 1000.

2. Low Frequency outputs (F1 and F2) which are suitable for directly dirving stepper motors or impulse counters.

3. The AD7751 has a Fault detection capability. When the Phase and Neutral currents differ by more that 20% then a logic output becomes active and power is calculated using the larger of the two currents.

4. There is a reverse-indicator output which becomes active when negative power is detected.

5. Choice of high frequency outputs for calibration

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AD7751–SPECIFICATIONS[1]

(V_{DD} = 5V ± 5%, AGND = 0 V, DGND = 0V, REFIN = +2.5 V,CLKIN = 3.58MHz TMIN to TMAX = -40°C to +85°C)

Parameter	A Version -40°C to +85°C	Units	Test Conditions/Comments
ACCURACY			
Measurement Error[2]			Channel 2 with Full Scale Signal.
Gain = 1	0.1	%Reading typ	Measured over a dynamic range on channel 1 of 500:1
	0.3	%Reading typ	Measured over a dynamic range on channel 1 of 1000:1
Gain = 16	0.3	%Reading typ	Measured over a dynamic range on channel 1 of 500:1
	0.5	%Reading typ	Measured over a dynamic range on channel 1 of 1000:1
Phase Error Between Channels			CLKIN = 3.58MHz, Line Frtequency = 50Hz
Phase Lead 40° (PF = +0.8)	±0.2	Degrees(°) max	HPF filter on, ACDC = 1
Phase Lag 60° (PF = -0.5)	±0.2	Degrees(°) max	HPF filter on, ACDC = 1
Feedthrough between Channels			HPF filter on, ACDC = 1, Mode 3, Channel 1= 0V
Output Frequency Variation (FOUT)	0.001	%Full Scale max	Channel 2 = 500mV rms a t 50Hz
Power Supply Rejection			HPF filter on, ACDC = 1, Mode 3, Channel 1 =0V
Output Frequency Variation (FOUT)	0.03	%Full Scale max	Channel 2 = 500mV rms, Power Supply ripple 250mV at 50Hz
ANALOG INPUTS			
Maximum Signal Levels	±1	V max	On any input, V_{1+},V_{1-},V_{2+} and V_{2-}. See Analog Inputs
Input Impedance (d.c)	400	kΩ min	CLKIN = 3.58 MHz
Bandwidth	14	kHz typ	CLKIN = 3.58 MHz, CLKIN/128
Offset Error	±10	mV max	
Gain Error	±2.5	% Full Scale typ	
Gain Error Match	±0.5	%Full Scale max	
REFERENCE INPUT			
REF_{IN} Input Voltage Range	2.75	V max	2.5 V +10%
	2.25	V min	2.5V -10%
Input Impedance	50	50	50 kΩ min
Input Capacitance	10	10	10 pF max
ON-CHIP REFERENCE			Nominal 2.5V
Reference Error	±250	mV max	
Temperature Coefficient	50	ppm/°C typ	
CLKIN			
Input Clock Frequency	4.5	MHz max	
	2	MHz min	
LOGIC INPUTS			
FS, S1, S2, ACDC and G1			
Input High Voltage, V_{INH}	2.4	V min	V_{DD} = 5 V ± 10%
Input Low Voltage, V_{INL}	0.8	V max	V_{DD} = 5 V ± 10%
Input Current, I_{IN}	±3	µA max	Typically 10nA, V_{IN} = 0V to V_{DD}
Input Capacitance, C_{IN}	10	pF max	
LOGIC OUTPUTS[3]			
F1and F2			
Output High Voltage, V_{OH}			I_{SOURCE} =10mA
	4	V min	V_{DD} = 5V ±10%
Output Low Voltage, V_{OL}			I_{SINK} = 10mA
	1	V max	V_{DD} = 5V ± 10%
F_{OUT} and REVP			
Output High Voltage, V_{OH}			I_{SOURCE} =1mA
	4	V min	V_{DD} = 5V ±10%
Output Low Voltage, V_{OL}			I_{SINK} =1mA
	1	V max	V_{DD} = 5V ± 10%

Parameter	B Version -40°C to +85°C	Units	Test Conditions/Comments
POWER SUPPLY			For specified Performance
V_{DD}	4.75	V min	5V - 5%
	5.25	V max	5V +5%
I_{DD}	5	mA max	Typically 3mA

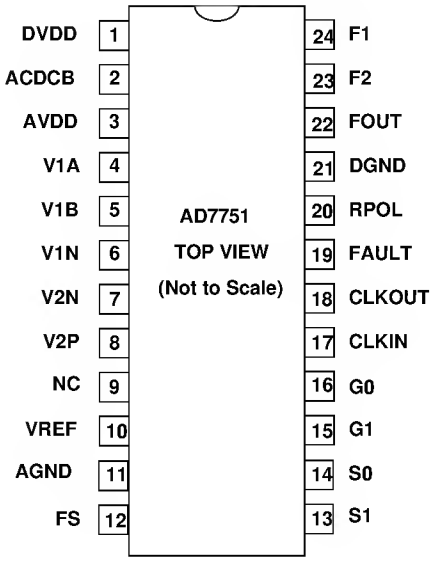
NOTES:
1 All Specifications Subject to change without notice
2 See Plots in Typical Performance Graphs
3 External current amplification/drive should be used if higher current source and sink capabilities are required, e.g. bipolar transistor.

AD7751 TIMING CHARACTERISTICS[1,2] (V_{DD} = 5V, AGND = 0 V, DVDD = 0V, REFIN = REFDUT. All Specifications T_{MIN} to T_{MAX} unless otherwise noted.)

Parameter	B Versions	Units	Test Conditions/Comments
t_1[3]	275	ms	F1 and F2 pulse width (logic low)
t_2	See Table 1	s	Output pulse period. See Table 1 to determine the output freuency
t_3	½t_2	s	Time between F1 falling edge and F2 falling edge
t_4[3]	90	ms	FOUT pulse width (logic higfh)
t_5	See Table 1	s	FOUT pulse period, See Table 1 to determine the output frequency

NOTES
[1] Sample tested during initial release and after any redesign or process change that may affect this parameter. All input signals are measured with tr = tf = 1 ns (10% to 90% of +5 V) and timed from a voltage level of +1.6 V.
[2] See Figure XX.
[3] The Pulse widths of F1, F2 and FOUT are not fixed for higher output frequencies. See the section called Digital to Frequency (DTF) for an explaination.
Specifications subject to change without notice.

PIN CONFIGURATION SOIC & DIP PACKAGES



ORDERING GIUDE

Model	Package Option*
AD7751AN	N-24
AD7751AR	R-24

* N = Plastic DIP; R = Small Outline IC (SOIC)

ABSOLUTE MAXIMUM RATINGS*

(T_A = +25°C unless otherwise noted)

V_{DD} to AGND ..... –0.3 V to +7 V
V_{DD} to DGND ..... –0.3 V to +7 V
Analog Input Voltage to AGND
  V_{1A}, V_{1B}, V_{2P} and V_{2N} ..... -6V to +6V
Reference Input Voltage to AGND .... –0.3 V to V_{DD} + 0.3 V
Digital Input Voltage to DGND ..... –0.3 V to V_{DD} + 0.3 V
Digital Output Voltage to DGND .... –0.3 V to V_{DD} + 0.3 V
Operating Temperature Range
  Commercial (A Version) ..... –40°C to +85°C
Storage Temperature Range ..... –65°C to +150°C
Junction Temperature ..... +150°C
24 Lead SOIC Package, Power Dissipation ..... 450 mW
  θ_{JA} Thermal Impedance ..... 74°C/W
  Lead Temperature, Soldering
    Vapor Phase (60 sec) ..... +215°C
    Infrared (15 sec) ..... +220°C
24Pin Plastic DIP, Power Dissipation ..... 450 mW
  θ_{JA} Thermal Impedance ..... 102°C/W
  Lead Temperature, Soldering
    Vapor Phase (60 sec) ..... +215°C
    Infrared (15 sec) ..... +220°C

*Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those listed in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

CAUTION

ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although the AD7751 features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.